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FiberLean ™: An innovative Composite Material

Andrew Findlay, Leslie McLain, Janet Preston, Kapil Dev Sohal

Imerys Minerals (India) Pvt. Ltd.

Abstract: *This presentation describes a novel process of producing micro-fibrillated cellulose (MFC) and its uses in recycled board. It can be produced on-site at a paper or board mill in units of robust and reliable equipment of relevant industrial scale using mill pulp and can be tailor made for specific customer needs. The use of FiberLean, which is a composite of MFC and mineral, offers paper and board producers simultaneous benefits of savings in variable cost, equivalent machine efficiency and improved physical properties of the final product. This is possible because the composite allows significant replacement of fibre with filler whilst increasing wet tensile and internal bond properties of most grades. The additional filler loading mitigates the retardation in drainage seen with MFC and production rates on paper machines over a wide range of basis weights. The amount of mineral present in the MFC/mineral composite can be modified depending on the final usage. Lower amounts of mineral allow maximum strength improvement, and higher amounts allow best possible cost-savings and improvement in coating hold out and optical and surface properties. The presentation includes a case study which highlights the potential of using FiberLean produced from recycled fibre in white top liner board.*
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Key words: Micro-Fibrillated Cellulose, Paper and Board, Increased Filler Loading

1. Introduction

The benefits of mineral fillers in fibre based paper and packaging are well known and documented ([i]). These include: improved optics, surface aspect, printability, smoothness and cost reduction due to replacement of fibre by mineral. However, high amounts of filler also results in reduced strength and bulk of the final paper and reduced wet strength of the paper web as it passes through the paper machine ([ii],[iii],[iv]).

There are many chemical additives known within the industry to increase dry strength; for example cationic starch, and synthetic strength resins ([v]); however too high a concentration of these can negatively impact the chemical and charge balance of the system, thus affecting sheet formation and quality. They also have little impact on the wet strength of the paper web during production.

A recent alternative material that is proposed to overcome many of the negatives associated with use of high filler amounts as well as maximising wet and dry paper strength is micro-fibrillated cellulose (MFC). However, conventional routes of production of MFC are both very expensive and limited in volume.

This paper introduces a new technology for the production of MFC which overcomes many of the problems with traditional MFC. We describe this new material, and give examples of its performance in laboratory and industrial trials which demonstrate its potential for cost effective, high levels of fibre replacement.

1.1 Traditional MFC

Microfibrillated cellulose was first made in the 1980's by Herrick et al.([vi]) and Turbak et al.([vii]) who demonstrated that the individual fibres in cellulose pulp could be separated (defibrillated) into a network of much small individual fibrils, thus creating a fibrous gel with a very high surface area and a very high number of potential bonding sites ([viii]). An analogy might be the separation of a single piece of rope in to all its constituent strands to form a high volume, low density entangled 3D web of fibre.

The production of traditional MFC requires a very high energy demand (>25-30 MW hr/T) and involves expensive and sophisticated grinding or homogenising equipment. It is therefore expensive and has a very high capital investment to capacity ratio.

Improvements to the initial invention include pre-treatments to soften up the fibres ([ix]) which significantly reduces the energy demand but does not influence the CAPEX to capacity ratio. In addition, these products are often difficult to handle being produced at very low solids with a gel like structure.

1.2 FiberLean ™

FiberLean ™ is a patented invention which uses mineral particles to facilitate the defibrillation cellulose fibres. Each mineral particle is used as a micro-grinding site to efficiently transmit grinding energy into the fibre.

The use of mineral to provide this highly targeted input of energy significantly reduces the cost of the process, and, especially in paper making applications, the mineral does not need to be removed after grinding, but actually provides additional benefits. Indeed, the ultimate aim often is to increase the total amount of mineral in the paper since it contributes to the improved opacity, glossability, printability and reduced cost of the final product.

Other advantages include the fact that the FiberLean ™ process can produce high volumes of mineral / MFC composite with relatively low CAPEX investment, and that if necessary, the product can also be dewatered to 30% solids and then re-dispersed without issue. Onsite production at a paper or board mill is practical since no pre-treatment of fibre is required and the process only requires readily standard and routinely available equipment that is well known in the mineral and pulp processing industries.

The FiberLean ™ process generates a network of fibrils and mineral particles in which the fibrils are relatively coarse with low surface charge. This allows good retention of both fibre fines and filler and good entrapment of filler within the paper web with minimal impact on wet end chemistry. The increased bonding potential allows higher interfibre bond strength thus allowing more filler to be included for the same final paper strength. The FiberLean ™ process is effective with all types of minerals as shown in Figure 1.

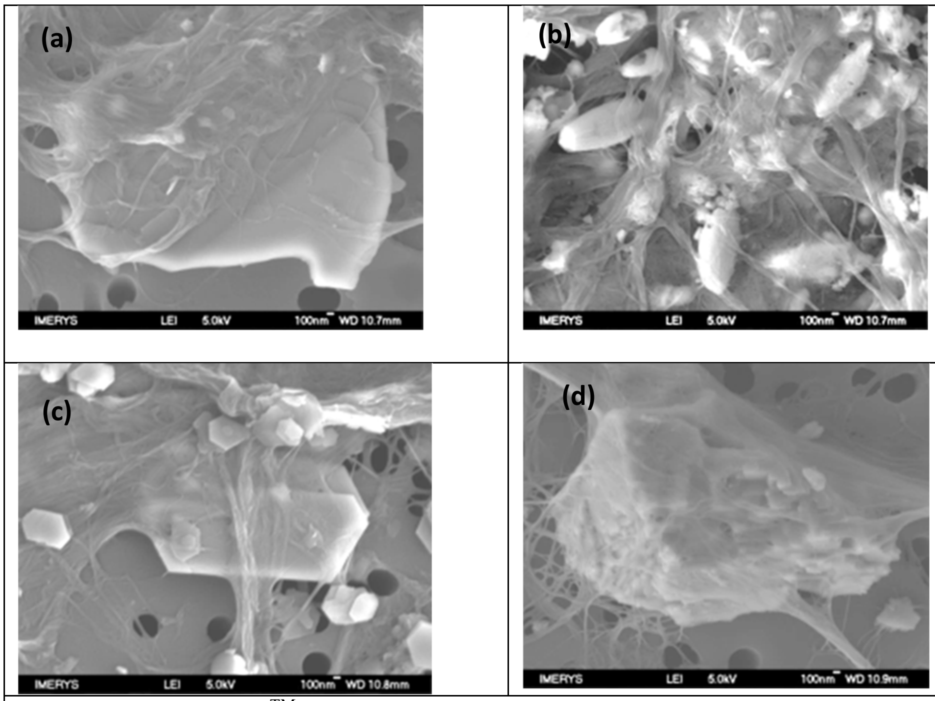


Figure 1. FiberLean ™ examples using different minerals (a= talc, b=PCC, C=kaolin, d=GCC)

2. Performance Observations

Typically, use of mineral/ MFC composites with a concomitant filler increase is associated with:

- ✓ Excellent performance stability
- ✓ Increased initial wet web strength
- ✓ Minimal impact on wet end chemistry
- ✓ Overall positive impact on drainage
- ✓ Improved dry mechanical properties
- ✓ Improved opacity
- ✓ A much tighter sheet (reduced porosity)
- ✓ Improved coating hold out
- ✓ Improved smoothness
- ✓ Maintaining bulk when fibre is replaced by higher specific gravity filler is a challenge but can be managed

These benefits are summarised in Figure 2 below.

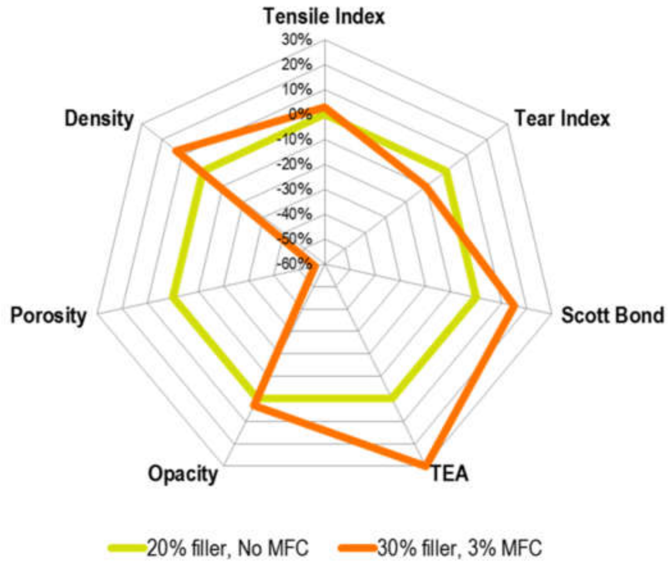


Figure 2. Benefits of MFC

2.1 FiberLean^{TM} can be made out of most pulps including recycled fibre

It is possible to prepare effective mineral/ MFC composites from:

i. A wide range of pulp types including bleached and unbleached softwood and hardwood kraft pulps and sulphite pulps.
ii. From broke and recycled streams.

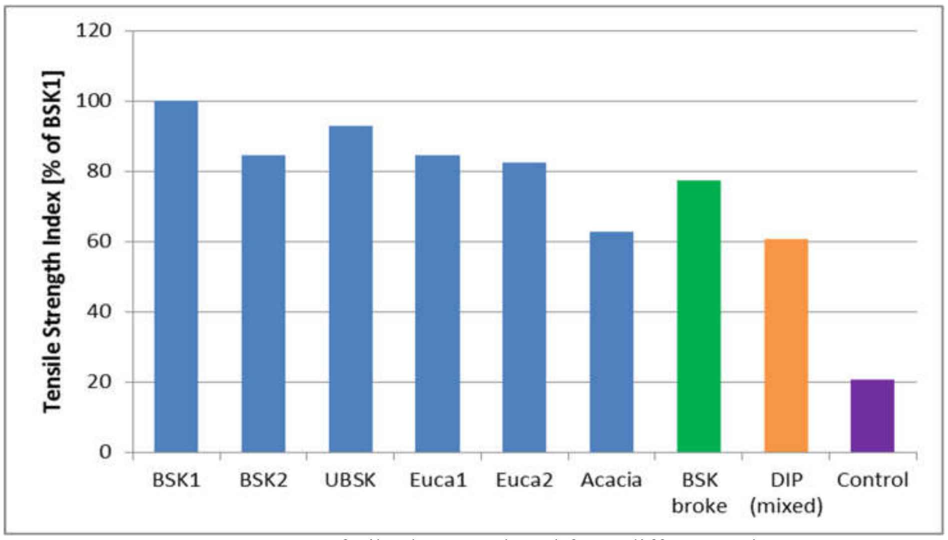


Figure 3. FLT of Fiberlean produced from different pulps.

3. Results

The following section presents results from laboratory and industrial trials in white top board where FiberLean^{TM} produced from good quality recycled fibre has been demonstrated to extend the limitations of standard board production. Figure 4 shows that good quality deinked pulp can be used to produce good quality Fiberlean however, it should be noted that the performance follows the expected trend in general quality that is usually seen between DIP and virgin fibre.

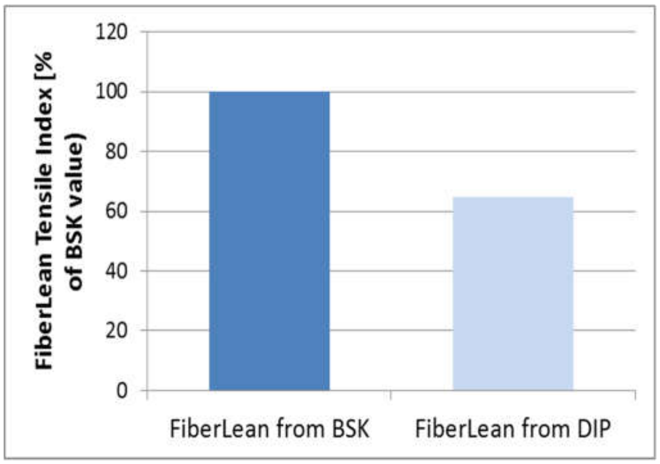


Figure 4. FiberLean Tensile Index of Fiberlean from virgin BSK pulp and Deinked Recycled pulp.

3.1 MFC in single and double ply handsheets

A laboratory investigation (Figure 5) using FiberLean from recycled pulp showed that in a single ply (80gsm) sheet, the MFC present allows significant increases in strength and optics. In this study an increase in ash content of 9% (from 31% to nearly 40%) increased CIE Whiteness by 5 units without the usual loss in internal strength (burst and Scott bond) that is associated with higher filler levels.

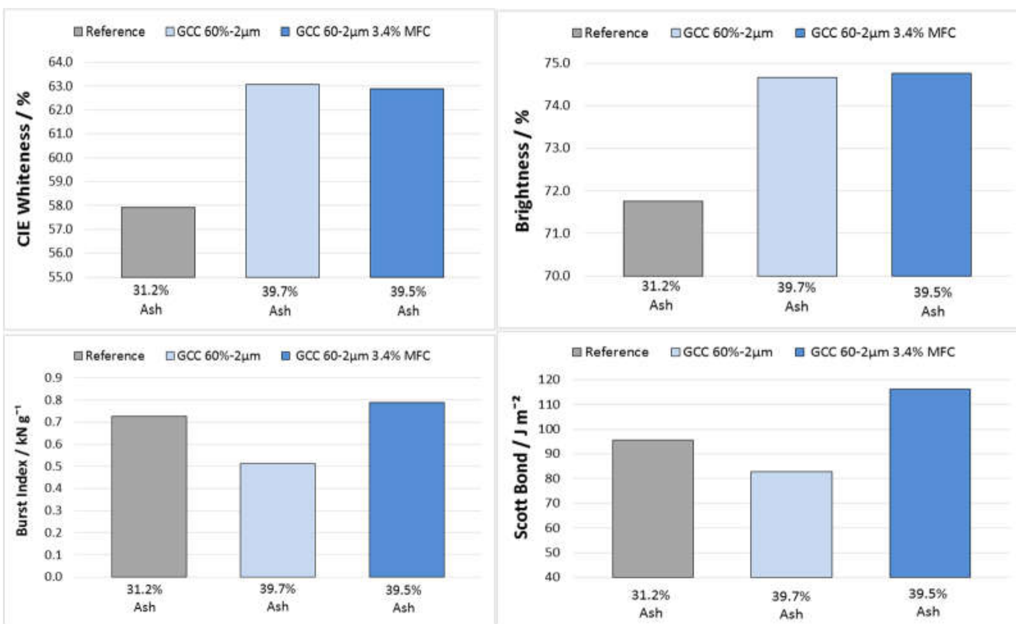
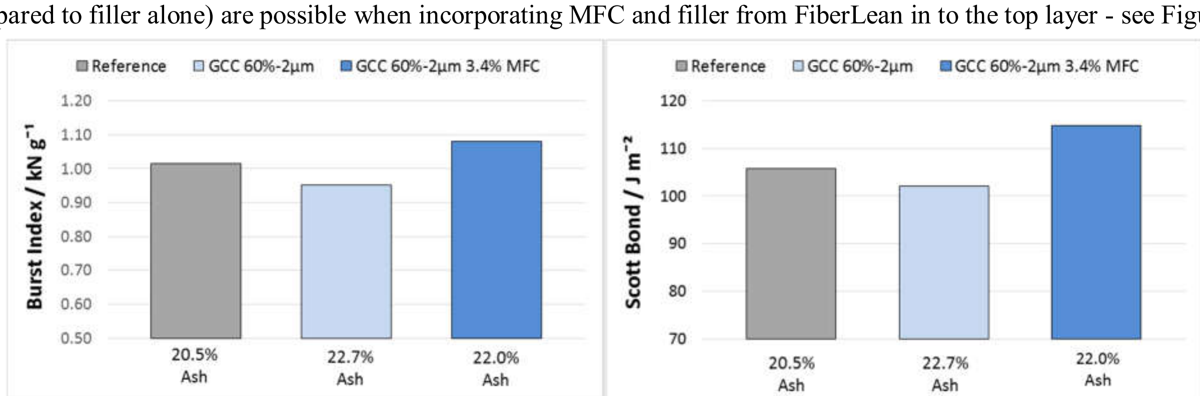


Figure 5. Benefits of MFC in 80gsm handsheets.

These single ply results were then confirmed in a double ply study. Measurements on a composite composed of a 40gsm top ply layer annealed to a 100 gsm lower brown layer again confirmed that simultaneous increases in strength and optics (compared to filler alone) are possible when incorporating MFC and filler from FiberLean in to the top layer - see Figure 6.



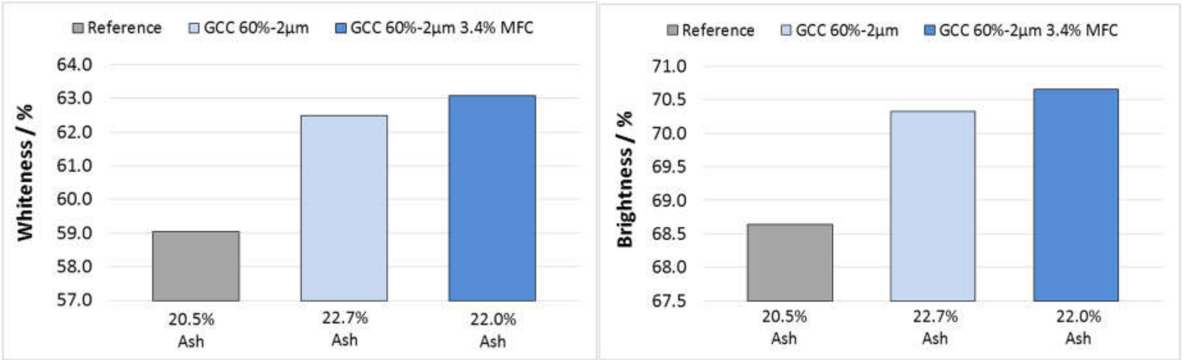
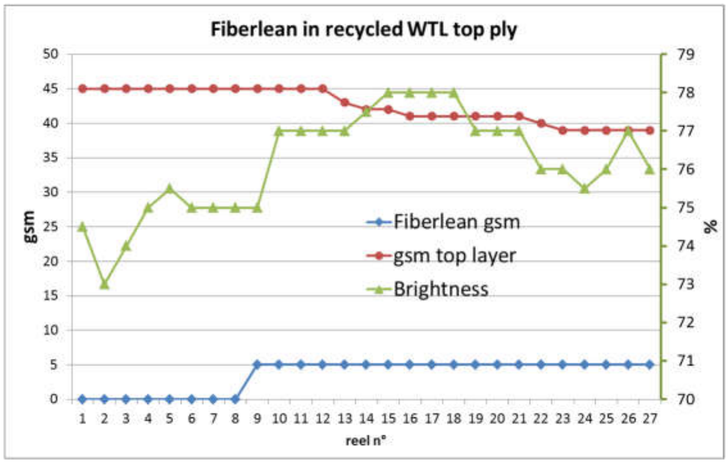


Figure 6. Benefits of including MFC in a 40gsm top ply on top of a 100gsm brown ply.

3.2 Industrial trial results

An industrial trial then confirmed that inclusion of FiberLean (5gsm) in the top ply of a white top board can allow a 5gsm reduction in the White Top Layer (45 to 40gsm) whilst increasing brightness by > 2 units.



4. Conclusion

This paper has shown that the use of MFC and in particular FiberLean TM in recycled board can create some exciting new opportunities for new products and cost reduction.

Mineral/ MFC composites can be prepared with virgin pulps (eg. softwood and hardwood kraft pulps), uncoated and coated broke and recycled fibres (good quality). Most of the minerals commonly found in paper and board industry can be used to produce mineral/ MFC composites with both high and low levels of mineral components

A case study for uncoated recycled kraft liner board demonstrated how MFC produced from good recycled fibre can give good performance in terms of strength and optics.

MFC redefines the world of composites and in the future will significantly influence the way in which many types of materials are made.

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